EFFECT OF THE CROSSINOLOGY® BRAIN INTEGRATION TECHNIQUE (BIT) ON CORTICAL ACTIVITY, AUDITORY SHORT-TERM MEMORY PERFORMANCE AND READING COMPREHENSION.

by Susan McCrossin, AP
LEARNING ENHANCEMENT CENTER LLC
2349 Doyle Drive, Berthoud, Colorado, USA 80513
Phone: (303) 449 1969
www.crossinology.com

Abstract

This pilot study describes, for the first time, changes in SSVEP topography associated with the performance of an attentional and a decision making task before and after acupressure treatment designed to improve learning abilities. Five subjects demonstrated predominantly occipito-parietal SSVEP activity prior to acupressure treatment which changed to predominantly pre-frontal activity following treatment on both tasks which suggests increases in attentional and decision making abilities. Averaged digit span for subjects increased from 5 $\pm$0.6 digits forwards to 7.4 $\pm$0.5 and from 3.8 $\pm$0.4 digits backwards to 6.8 $\pm$0.8. Reading comprehension on the Neale Reading Ability Test increased from 35% $\pm$20 S.D. to 100% $\pm$0 S.D. The clinical significance was confirmed by post-treatment interviews with all subjects who stated significant improvements had occurred in their learning abilities. The results suggest the SSVEP measures of changes in cortical activities are correlated with quantitative improvement in digit span and reading comprehension.

Introduction

Since learning at the conscious level appears to involve activation of Gestalt and Logic functions at the level of the cortex, I investigated the affects of the BIT acupressure protocol on cortical activity. I also decided to measure affects of the BIT on two other parameters often associated with learning problems, auditory short-term memory and reading comprehension problems, using standard psychological testing.

Previous studies (Silberstein et al., 1995) have demonstrated that a recently developed sophisticated type of EEG, Steady State Visual Evoked Potential (SSVEP), was capable of generating maps of cortical activity sensitive to cognitive processes. In SSVEP there are transient reductions in amplitude that appear to index regional increases in cortical activity associated with the performance of a cognitive task. Because it is possible to estimate the amplitude of the SSVEP using as little as 1 to 5 seconds of recorded activity, this technique was chosen to investigate changes in brain activity associated with attentional and decision making cognitive tasks.

In the SSVEP procedure a constant visual flicker was superimposed on the viewing field generating the cortical activity recorded by the SSVEP. This visual flicker generates a consistent 13 Hz sinusoidal wave form in the EEG pattern. Silberstein et al. (1995) have shown that cognitive tasks requiring attention and decision making cause a reduction in the amplitude of the SSVEP in the prefrontal cortex, suggesting increased activity, when paying attention and at the point of decision making.

The cognitive task chosen requires an individual to respond every time they see an X preceded by an A projected on a monitor screen. Anticipation and attention to the task is necessary to perform the task accurately. The appearance of an A thus primes the subject's attention in anticipation that an X may follow. When an X follows the A, the subject must make a decision to respond or if no X follows, decide not to respond. Under these conditions when the subject is primed there is a reduction in the SSVEP amplitude.

The digit span subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) is a measure of the auditory short term memory processing, where a subject repeats a verbally presented sequence of random numbers. The span or number of digits that can be accurately reported varies with age, varying from 3 forwards and 0 backwards for a 4 year old to 6 forwards and 5 backwards of an average adult. Deficit digit span is when the subject recalls fewer digits than is average for their age.

Reading comprehension is the ability to recall information about what was read shortly after reading it. Poor reading comprehension is expressed by the inability to recall much of the detail of what was read or to confuse or confabulate the information. Normal subjects can easily recall greater than 90% of the material read when tested within a few minutes of reading it. Individuals with poor comprehension can generally recall less than 50% and may recall almost nothing.

The Brain Integration Technique (BIT) has been developed empirically since 1989 and has been applied to the improvement of specific learning problems on several thousand subjects with generally excellent results. The BIT treatment employs a specific acupressure protocol to improve brain functions (McCrossin et al, 1994) that has been empirically demonstrated to reproducibly improve various learning dysfunctions including deficit Digit Span ability and poor reading comprehension.

Pre and post-testing of subjects undergoing the BIT protocol with WISC-R has shown marked improvement on all of the subtests (Paphazy, unpublished data). Improvement was consistently seen even on visuo-spatial subtests like Block Design which had not previously been observed to change over time, regardless of considerable periods of remedial treatment. Block design is often considered to be a measure of innate intelligence as it tests spatial reasoning not affected by acquired verbal knowledge.

After BIT treatment some subjects have shown an increase in the Block Design task from a previous ranking in the 25th percentile of same aged children to the 75th percentile and changes to as high as the 99.6 percentile have been recorded. Changes of equal magnitudes have been observed on all subtests, for instance from the 1st to the 50th percentile ranking on the Digit Span subtest.

In those cases where improvement was not observed or was marginal, either on several or on only a specific subtest, neurological assessment demonstrated varying degrees of organic brain damage in almost all cases (Dr. Graeme Jackson, personal communication). The damage observed varied from developmental problems such as neuronal migration problems, temporal lobe epilepsy, hypoxic damage resulting from birth difficulties or traumatic injury such as blows to the head.

Acupuncture or acupressure therapy consists of either stimulating or dispersing the flow of energy by activation of specific acupoints on the surface of the body. The acupoints have been accurately mapped using electrical detection because they have been found to be “null” points or points of least electrical resistance on the surface of the body. The electrical mapping is very highly correlated with Chinese maps of these same points (Kaptchuk, 1989; Maciocia, 1992; Porkert, 1985). The Chinese propose that energy, Ch’i, is a dynamic force in constant flux that circulates throughout the body but that follows specific pathways, the meridians, and obeys specific rules (Chang, 1976; Xinnong, 1990).

Traditional acupuncture techniques are stated to be helpful for strengthening cerebral function and improving intelligence (Qian-Liang, 1989). Abad-Alegria et al. (1995a) have shown that stimulation of a specific acupoint produced reproducible and sustained changes in the somatosensory evoked potential of intracortical origin. They also demonstrated that this physiological effect was specific to acupoint stimulation and did not occur when “sham” points were identically treated.

The purpose of the current study was to investigate whether the functional changes observed, after acupressure treatment for learning difficulties in Digit Span and reading ability, had a corollary in changed patterns of cortical activity as measured by the SSVEP.

Methods

Subjects

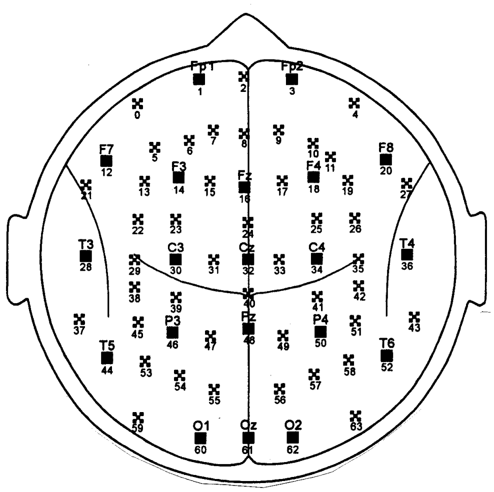
One male and four female subjects with a history of learning difficulties and persistent problems with reading comprehension volunteered to serve as subjects. All subjects gave their informed consent to participate in the study. Four were right handed and one was left handed as determined by the Edinburgh handedness inventory and ranged in age from 18 to 44 years (mean 30, S.D. 10). No subjects with a history of epilepsy were included in the study.

Due to individual variability in brain pattern, each subject was used as their own control and the current study is reported as five case histories.

Recording

Brain electrical activity was recorded from 64 scalp sites which included all International 10-20 positions with additional sites located midway between 10 and 20 locations (Figure 1). The specific locations of the recording sites are illustrated in Figure 1. The average potential of both earlobes served as a reference and a nose electrode served as a ground.

Figure 1. Location of recording sites with International 10-20 positions indicated.



Each subject performed these tasks and was scanned three times. The first trial was performed as a practice trial to familiarise the subjects with the protocol and eliminate any novelty effect. The second trial was to be used as a pre-treatment assessment of their SSVEP response. The third trial was performed after the BIT treatment.

Signal Processing

Analysis of the EEG signals was done by computerised analysis and is described in detail elsewhere (McCrossin, 1995). Basically, the baseline readings were subtracted from the "primed" decision-making readings to generate a map of cortical activity during Attention Primed Decision-making. In a similar manner, the attention "primed" with no decision (the A not followed by an X) readings were subtracted from the Attention Primed Decision-making readings to generate a map of cortical activity during making a decision.

BIT Acupressure Treatment Protocol

The BIT protocol is a multi-step procedure whereby acupoints, both individually and in specific combinations, are stimulated and assessed for activation. Acupoints or acupoint combinations demonstrating unbalanced activity were then rebalanced using a series of standard Applied Physiology techniques (Utt, 1985; 1989; 1991) based on the principles of the Law of Five Elements of Chinese Acupuncture and the Seven Element Hologram (Maciocia, 1992; Utt, 1992, 1994).

The initial BIT treatment for learning dysfunctions involves assessment and treatment of acupoints and acupoint combinations that have been empirically demonstrated to re-integrate and re-synchronise brain function for improved cognitive ability, which on average requires approximately 10-12 hours of treatment time. Deficit Digit Span and reading comprehension are two specific areas of dysfunction that often persist after these initial brain integration procedures are complete. Additional specific BIT formats are then employed to address these specific dysfunctions until no further improvement is observed.

These specific acupressure formats involve the performance of the specific cognitive task followed by immediate assessment and treatment of specific acupoints or acupoint combinations that have been activated by attempting the task. The cognitive task is then repeated until no further acupoints are activated by performing the task.

Digit Span Task
The Digit Span subtest of the WAIS-R involves two separate components, Digits Forwards and Digits Backwards using pairs of random digit sequences. The examiner reads aloud each sequence of random digits at the rate of one per second. After the last digit of the sequence has been read, the subject is then asked to recall the sequence in the order it was read for the Forward test and in the reverse order for Digits Backwards. For both tests subjects are first given the instructions and then practice sequence (e.g. 1, 2, 3) to make sure that they understand the procedure. After the practice procedure is completed correctly, the test begins.

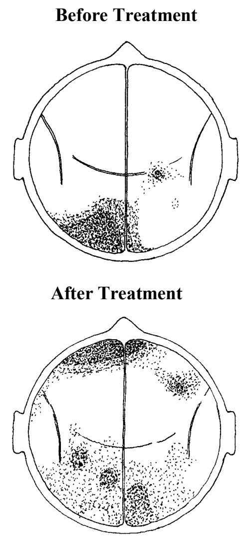
Reading Comprehension Task
To assess the subjects' reading comprehension the Level 6 Reading Comprehension subtest of the Neale Analysis of Reading Ability-Revised (1966) was administered to each subject. The number of correct answers to the 8 questions about each reading passage was converted to a percentage reading comprehension score. After the initial acupressure treatment to improve brain function, the subjects read a passage of equivalent difficulty to those in the Neale Test and their comprehension of the material read was verbally assessed. If reading comprehension was still less than 90%, the subject was immediately assessed and treated using specific BIT formats to rebalance any acupoints or acupoint combinations that became activated or unbalanced by their attempt to recall the detail of what they had read. The ability of each subject to comprehend what they had read was repeatedly challenged in this way until reading passages of equivalent difficulty to those on the Neale Test were fully comprehended. The subjects were then re-tested on the Neale subtest for reading comprehension and the result expressed as the percent of correct answers.

Results

Cognitive Task - SSVEP
Figure 2 presents examples of the SSVEP amplitude maps of the Decision-making and the Attention Tasks on both prior trials and the post treatment trial.

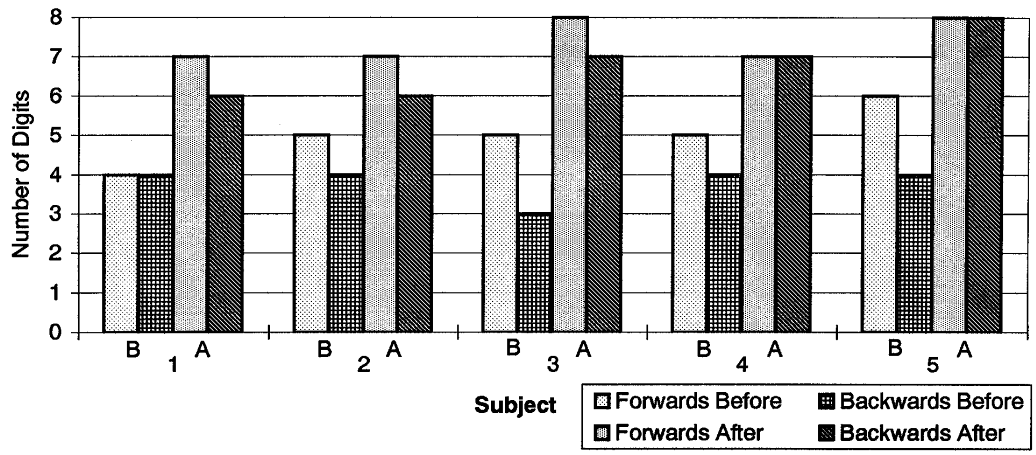
Although the activity maps for both tasks, Attention Primed and Decision-making, varied in detail between subjects, similar patterns were observed for both types of tasks. Prior to the BIT treatment, all subjects showed predominately occipito-parietal lobe activity with little or no frontal lobe activity. Following the BIT treatment, there was a considerable change in areas of activation with all subjects showing increased bilateral activation of the frontal lobes and with the lowest levels of cortical activity now in the occipito-parietal lobes.

Figure 2: Typical scalp topography of SSVEP amplitude difference maps before and after acupressure treatment. Stippling indicates degree of activity.



Digit Span Task
All subjects demonstrated deficit age-specific digit span varying from near average at 6 forwards and 4 backwards to considerably deficit at 5 forwards and 3 backwards. After BIT treatment the digit spans of all subject's were above the adult average of 6 forwards and 5 backwards, ranging from 7 forwards and 6 backwards to 8 forwards and 8 backwards (Figure 3).

Figure 3.
Forwards and Backwards Digit Span Before and After Acupressure Treatment for Learning Difficulties

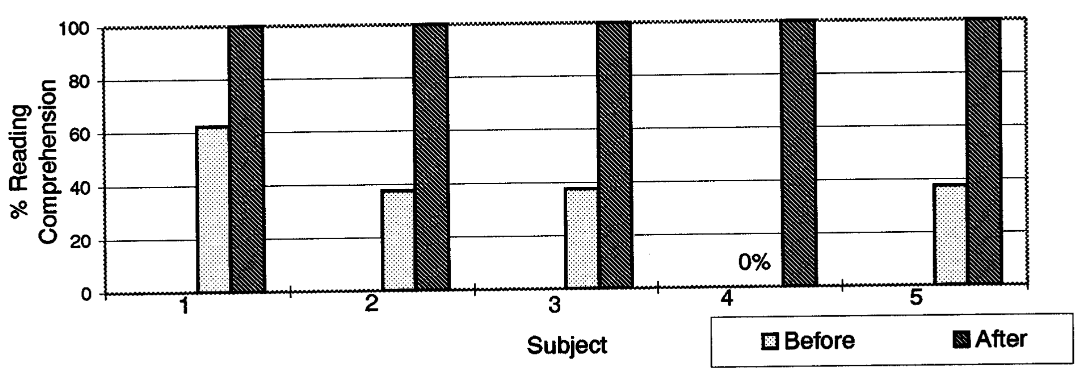


Reading Comprehension Task

The percentage of reading comprehension on the Neale Reading Analysis before treatment varied from 62.5% to 37.5% with one case of zero percent comprehension as this subject was unable to answer a single question correctly on the material read. After the BIT treatment for learning difficulties all subjects scored 100% on reading comprehension (Figure 4).

Figure 4.

Percentage Reading Comprehension on Neale Reading Test Before and After Acupressure Treatment for Learning Difficulties.



Discussion

The SSVEP amplitude maps for the pre-treatment Attention Task clearly shows a generalised pattern of increased occipito-parietal activity and generally little pre-frontal activity. The post-treatment maps all show the reversed pattern with the highest levels of activity in the pre-frontal areas and, in general, lesser activity in occipito-parietal regions (Figure 2). Increases in activity, suggesting pre-frontal activation, has been associated with the attentional components of a visual vigilance task (Silberstein et al., 1990). Such findings are consistent with neuropsychological studies indicating pre-frontal involvement in the mediation of attentional processes (Milner & Petrides, 1984; Roland, 1984).

The SSVEP amplitude maps for the pre-treatment Decision-making Task followed a similar pattern with most activity in the occipito-parietal region for most subjects and generally low activity in the pre-frontal areas. Following the BIT treatment, there was generally increased frontal activity with some evidence of parieto-temporal involvement (Figure 2). This is consistent with the observation of Ciorciari et al. (1992), Silberstein (1992) and Silberstein et al., (1995), that increased pre-frontal activity will peak at times when normal subjects are required to make decisions with regard to new sorting criteria on the Wisconsin Card Sorting Test (WCST). The pre-frontal focus of the increases observed in this study is consistent with neurophysiographic and neuro-psychological data indicating a critical role of the pre-frontal region at times of decision making (Nunez, 1995).

A recent study performed at SCAN studied the cortical activity pattern of children with Attention Deficit Disorder (ADD) and normal subjects. On attentional and decision-making tasks, ADD children consistently showed patterns of cortical activity similar to the subjects in this study before treatment with the greatest cortical activity in the occipito-parietal lobes and least activity in the frontal lobes. Normal subjects showed increased frontal activity on both types of tasks.

A number of studies have shown that paying attention and decision-making cause pre-frontal cortical activation, while passive looking at or watching visual stimuli generally only activates the occipito-parietal cortex. Thus, it appears that people with ADD and learning problems often just watch their world, and react to whatever happens with little anticipation of what will happen because they can not activate the brain areas involved in “paying attention” required for anticipating outcomes.

Likewise, since pre-frontal activity is required for “planned” decision-making, and there is little pre-frontal activity when people with ADD and learning problems make decisions, it would appear these decisions must depend more on “reaction’ to stimuli than on “planned” actions based on considered decisions.

Therefore, the results of the current study demonstrate that the BIT treatment is capable of producing changes in cortical activity consistent with increased attentional and decision making capabilities in individuals displaying learning problems. The patterns of cortical activity, as measured by SSVEP mapping, change from those typical of ADD individuals to those observed in normals performing similar tasks.

Digit Span

From my experience, many children and adults who have learning difficulties generally display a large disparity between their Forward and Backward Digit Span, with a difference of 2 or more digits between their Forward and Backward scores common.

Digits Forward

What Digits Forward measures is more closely related to the efficiency of attention than to what is commonly thought of as memory (Lezak, 1983).

Taking into account that the normal adult range for Digits Forward is 6±1, and that education appears to have a decided effect on this task, it is well *within normal limits* to have a span of 6 or better, while a span of 5 may be *marginal* compared to normal limits. A digit span of 4 is definitely *borderline*, while a span of only 3 is defective for adults (Lezak, 1983).

Four of the five subjects in the current study clearly had marginal to deficit digit span function prior to treatment, with only one subject demonstrating an average forward digit span. After the BIT treatment for the correction of digit span, all subjects improved significantly increasing their forward digit span by 2 or 3 digits. This again supports the results of the SSVEP data suggesting that the BIT protocol is capable of increasing the attentional ability of the subjects.

Digits Backward

People can usually remember the same or one less Digits Backwards as they can Digits Forward. A backwards score of 5 is therefore considered to be *within normal limits*, 4 is *marginal*, 3 is *borderline defective* or *defective*, depending on the subject's educational background and 2 is *defective* for persons up to the age of 60 (Lezak, 1983). Before BIT treatment, all subjects demonstrated marginal to borderline backwards digit span function.

The Digits Backward task requires not only storing a few data bits briefly, but also juggling them around mentally. It is inherently a more difficult task requiring not only attention as in the case of the more passive Digits Forward task, but the use of working memory as well. Lezak (1983) states that it is therefore more of a memory test and involves mental “double-tracking” in that both the memory and the reversing operations must proceed simultaneously. It is suggested that the ability to reverse digits, or to spell a word or recite a letter sequence backwards, is "probably characteristic of normal cognitive function and language processes" (Bender, 1979 cited in Lezak) related to the brain's normal function of temporal ordering.

Lezak (1983) suggests the reversing operation depends upon internal visual scanning. I have found, and Lezak states also, that most normal adults, when asked to spell a word backwards will report when questioned afterwards that to perform the task they moved their eyes in response to a mental visual scanning approach to the task, so that the concept of linking the capacity to reverse digits to visual scanning efficiency appears to be well founded.

Damasio (1994) has shown that working memory predominantly requires pre-frontal and dorsolateral frontal activity. The post-treatment results of the SSVEP analysis, on the decision making task, suggesting increased frontal and pre-frontal activity is consistent with the significantly increased ability of the subjects to perform the Digits Backwards task. The subjects increased their digits backwards from 4 or 3 before treatment to 6 to 8 digits backwards post-treatment. This magnitude of increase in the working memory would seem to necessitate an increase in the cortical activity supporting this working memory region. Therefore, the increase in the digits forwards task from an average of 5 ±0.6 to 7.4 ±0.5 and the increase in digits backwards from an average of 3.8 ±0.4 to 6.8 ±0.8 is supportive of significant change in cortical activity seen in the SSVEP results. The subjects all changed from being marginal or borderline in their function to all being above average, suggestive of efficacy of the BIT treatment in normalising brain function.

Reading Comprehension

While reading is an extremely complex mental process requiring the integrated function of many parts of the brain simultaneously, the goal of reading is comprehension. It requires a diverse number of perceptual and cognitive functions. In fact reading is such a demanding process that skilled performance - extracting meaning from words while moving with fluidity down the printed page - requires highly automated application of many separate skills. If one or more of these skills are insufficiently developed, they will compete for attentional resources in our limited working memories, and performance on the composite task will decline (McLoughlin & Lewis, 1994).

The SSVEP results and the digit span results both suggest that following BIT treatment, attention and the ability to use working memory appear to have improved. Therefore, it is not surprising to see the significant improvements in reading comprehension from generally below 50% of the material read, before treatment, to 100% of the material read, after treatment. For all subjects to now have 100% reading comprehension, which is reliant on a diverse number of perceptual and cognitive functions, would indicate that the BIT treatment caused widespread improvement in perceptual and cognitive abilities.

Subject Feedback

To demonstrate the clinical significance of the treatment, subjective comments from the subjects in the study is included below:

Subject 1.

- my co-ordination has improved and I am no longer clumsy.
- my communication skills have improved. While I used to know what to say in my head, the words were muddled on the way out, this has improved 80%.
- I don't fall asleep after reading half a page as before, I am happy to read. It is no longer a chore and my eyes don't sting.
- I used to find the course I am studying very stressful and draining, especially before exams. The last exam was a breeze and I walked into the exam room completely calm.

Subject 2

- I have noticed a significant improvement in my ability to visualise concepts and ideas.
- I am finding it easier to organise and work around timetables.
- my spelling is starting to improve.

Subject 3

- I feel a stronger sense of self and inner strength.
- others comment that I am more relaxed.
- I am now able to read my texts with understanding.
- I am now comprehending anatomy and physiology lectures and not feeling it is a foreign language.

- I have better comprehension and attention in both reading and listening.

Subject 4

- There has been a significant improvement in my ability to maintain focus and concentration.
- others remark on a complete change in me, I am now more focused and ‘present’ where as I used to ‘drift off’.
- I am now able to keep focused during class with no effort.

Subject 5

- my thinking is clearer.
- I am more logical.
- my attitude is calmer.

It is clear from the above statements that all subjects appear to have benefited significantly from this treatment and now appear to feel better about themselves as well as learn with less stress and greater ease.

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